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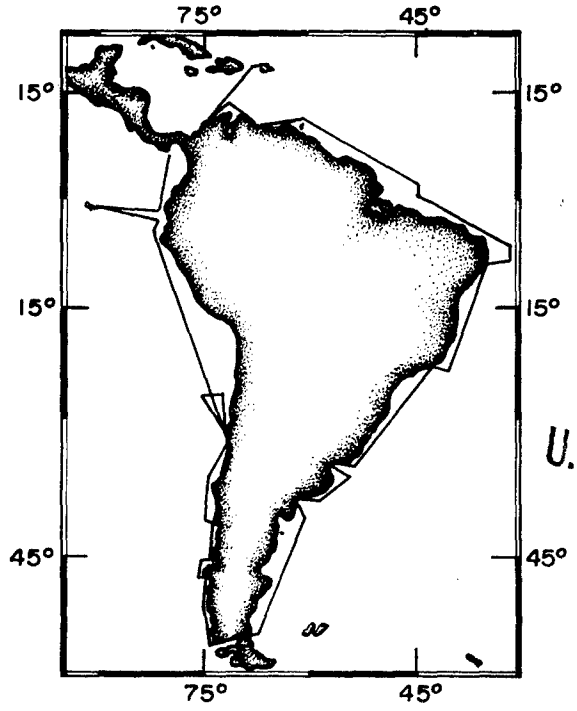
INFORMAL REPORT

OCEANOGRAPHIC CRUISE SUMMARY
UNITAS IX CRUISE
AROUND SOUTH AMERICA
JULY TO OCTOBER 1968



MARCH 1969

NAVAL OCEANOGRAPHIC OFFICE
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INFORMAL REPORT

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ABSTRACT

Oceanographic operations were conducted aboard U.S. Navy ships during the UNITAS IX cruise around South America. The cruise began in mid-July and lasted until the end of October 1968. Six Nansen cast stations were taken in tropical regions close to the coast of Brazil, and bathythermograph and bathymetric observations were made throughout the cruise.

A prominent feature at all of the Nansen cast stations was a salinity maximum at about 100 meters (328 feet) caused by the presence of Subtropical Underwater. Maximum sound velocities generally were found near the bottom of the layers influenced by wind mixing. Also, a deep sound channel appeared to be present within the Antarctic Intermediate Water at a depth of approximately 800 meters (2,625 feet).

Layer depths indicated by expendable bathythermograph observations ranged from 0 to the maximum depth of 1,000 feet. Deep layers were common in the Falkland and Brazil Current confluence region, in the Strait of Magellan, and in Chile's inter-island region. Shallow layer depths appeared to be common in waters influenced by the outflow of the Amazon and Orinoco Rivers and in the waters of the Peru Current.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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Director, Nearshore Surveys Division

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I. NARRATIVE OF THE SURVEY

From mid-July to the end of October 1968, U.S. Navy Task Force 86 participated in UNITAS IX, a series of cooperative naval exercises with various South American nations. Four ships were attached to Task Force 86: USS CHOPPER (SS 342), USS DAMATO (DD 871), USS JOSEPHUS DANIELS (DLG 27), and USS McCLOY (DE 1038). Before McCLOY left home port, the Naval Oceanographic Office (NAVOCEANO) equipped her with an oceanographic winch and a portable van which could serve as an office and laboratory.

Two NAVOCEANO oceanographers carried out an oceanographic program (operation number 929005) during UNITAS IX. The first boarded McCLOY on 15 July in San Juan, Puerto Rico, and was relieved in Buenos Aires, Argentina, on 31 August. The second oceanographer left McCLOY on 26 October at Rodman, Panama Canal Zone. A second class aerographer's mate from Carrier Division 16 was assigned to McCLOY in San Juan to assist with the oceanographic program.

During most of the underway periods, expendable bathythermograph (XBT) drops were made at frequent intervals by both DAMATO and McCLOY. A total of 600 XBT's was collected throughout the survey. A smaller number of conventional BT's were collected by JOSEPHUS DANIELS. The oceanographic equipment placed aboard McCLOY was used to occupy six oceanographic stations (Table I) between 6 and 10 August (Fig. 1).

Oceanographic lectures were given to naval officers in Argentina and Chile, and fruitful discussions were held with personnel of the Argentinean and Chilean hydrographic offices.

TABLE I. OCEANOGRAPHIC STATION SUMMARY

Station Number	Latitude	Longitude	Sonic Depth		Temp.	Salinity	Micro-Nutrients
			Meters	Feet			
1	3°29.5'N	45°00.5'W	3,912	12,834	√	√	√
2	2°30.0'N	45°00.0'W	3,885	12,746	√	√	√
3	1°44.5'N	44°48.0'W	3,912	12,834	√	√	√
4	4°59.0'S	32°02.0'W	3,071	10,075	√	√	√
5	6°00.0'S	32°00.0'W	4,113	13,494	√	√	√
6	6°58.0'S	31°56.0'W	4,844	15,892	√	√	√

II. OBJECTIVES OF THE SURVEY

The objectives of the oceanographic phase of UNITAS IX were the following:

- collect and analyze data relevant to ASW/USW operations
- occupy Nansen cast stations in regions where data are sparse
- present military oceanography lectures to representatives from participating countries
- visit oceanographic institutes in South America in order to learn more about their research activities.

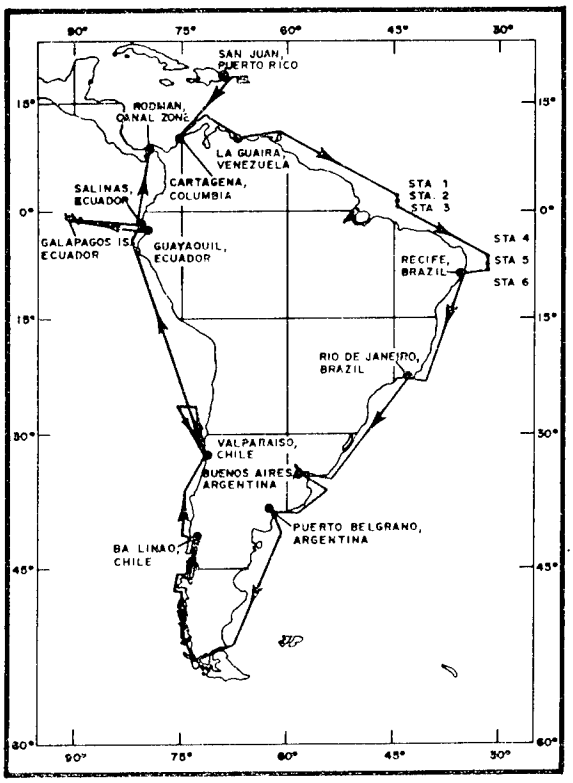

Figure 1. UNITAS IX Itinerary

III. PREVIOUS KNOWLEDGE OF THE REGION

A very general picture of the surface currents (for austral winter) in the regions traversed during UNITAS IX is presented in Figure 2. Martineau (1953) shows it is possible that water similar to Antarctic Intermediate Water may form off the east coast of South America in regions where mixing takes place between the cool, north-setting Falkland

Current and the warm, southward-flowing Brazil Current. A countercurrent has been shown to exist beneath the cool, north-flowing Peru Current which is found off the west coast of South America, and upwelling is known to be common in areas transited by the Peru Current.

So many different oceanographic provinces were transited during UNITAS IX that a detailed description of all of the important oceanographic features would far exceed the scope of this report. Instead, the reader is referred to the many publications about the various regions, some of which are listed in the bibliography.

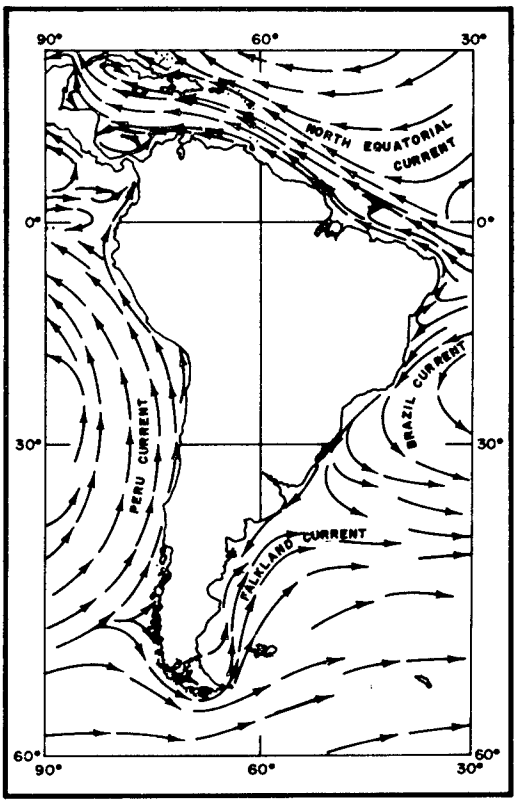

Figure 2. Surface Currents for Austral Winter

IV. METHODS OF COLLECTION AND ANALYSIS

A. Physical Oceanography.

1. Temperature. Paired protected reversing thermometers were used to obtain water temperatures at the oceanographic stations. Although agreement between paired thermometers was not as good as could be hoped for, most readings were within 0.05°C.

Using Sippican XBT systems, DAMATO and McCLOY collected 600 temperature-depth profiles. Most of the probes were designed to achieve a maximum sampling depth of 1,500 feet (457 meters), but a few 2,500-foot (762

meters) probes were employed. The relatively small number of mechanical BT's taken by JOSEPHUS DANIELS are not discussed in this report. All BT's were collected by ships' personnel. Analysis of the data revealed some errors; however, the BT information obtained during UNITAS IX is probably at least of better than average quality.

When interpreting the BT data, the possibility that the ships' turbulence may have "erased" some of the near surface features should be kept in mind. Even though XBT's sink rapidly, the launchers on DAMATO and McCLOY were located so far aft that the probes probably passed through turbulence created by the ships' screws, in addition to the turbulence resulting from the movement of the ships' hulls. It is also possible that individual probes may have malfunctioned on occasion.

2. Depth. Nansen cast sample depths were determined by the L-Z depth determination method described in N.O.O. Publication 607 (1968). Eighty percent of the unprotected thermometer readings yielded depths within 4 meters (13 feet) of the accepted sampling depths.

B. Chemical Oceanography.

1. Salinity. Salinity samples were analyzed aboard McCLOY with an Industrial Instruments Model RS-7B inductive salinometer. In addition to the normal standardizations with Standard Sea Water, substandard water samples were analyzed to check the instrument's accuracy, and a few of the earlier samples were re-examined to check the precision of the instrument.

2. Nutrient Samples. Sea water samples were drawn into six-ounce polyethylene bottles and frozen. They will be analyzed at NAVOCEANO for reactive phosphorus, nitrate, and reactive silicate. Unfortunately, operational difficulties sometimes caused delays of up to 3 hours between collecting the sample and placing it in the freezer.

C. Bathymetric Data.

Bathymetric data were collected by JOSEPHUS DANIELS and McCLOY using UQN-1G depth recorders. Due to the many course changes required by the Task Force operations and to the unsophisticated nature of the equipment, much of the bathymetric data may not be suitable for updating bathymetric charts.

V. DISPOSITION OF DATA

All XBT data were forwarded to Fleet Numerical Weather Central, Monterey, California. All mechanical BT and oceanographic station data were forwarded to the National Oceanographic Data Center (NODC).

The oceanographic station data have been filed under cruise reference number 311335. Once the nutrient analyses have been completed, the results also will be sent to NODC.

All bathymetric data will be evaluated and filed at NAVOCEANO.

VI. PRELIMINARY ANALYSES

A. Nansen Cast Stations.

Figures 3 and 4 present temperature, salinity, and sound velocity cross sections for the six oceanographic stations. The temperature section in Figure 3 appears more complicated than the other sections because XBT data obtained along the same line also were used in drawing the cross section.

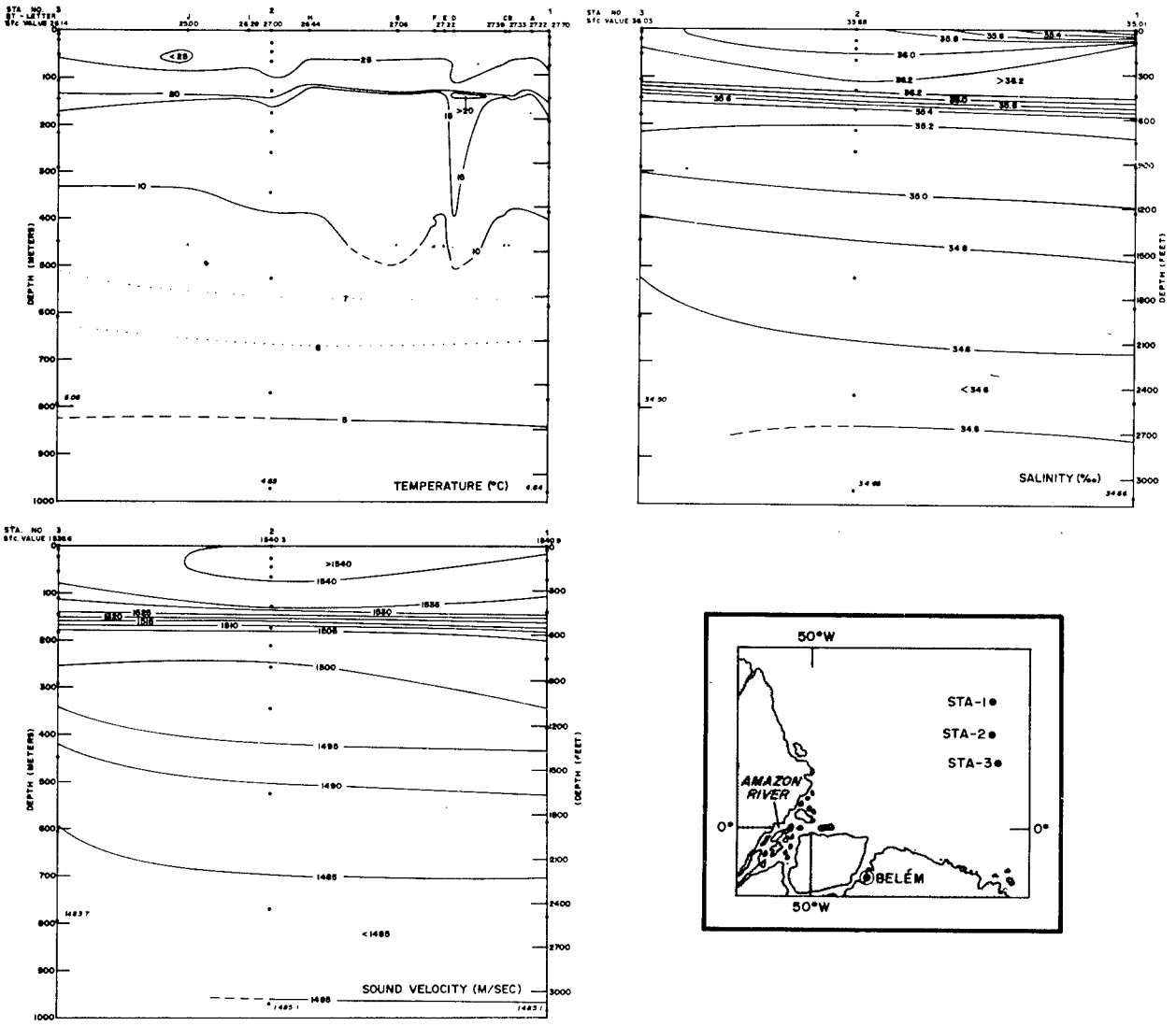

Figure 3. Temperature, Salinity, and Sound Velocity Cross Sections for Stations 1, 2, and 3

As might be expected in these equatorial regions, surface temperatures at all stations were high. In both temperature sections, the main thermocline appears to begin at depths between 50 and 100 meters (164 and 328 feet). The shapes of the isotherms in the vicinity of BT "D" (Fig. 3) could indicate dynamic features such as vortices or internal waves. However, it should be remembered that the observed isotherm distribution could also have been caused by malfunctioning probes.

Prominent features in the salinity sections are the salinity maximum at a depth of approximately 100 meters (328 feet) in both sections and the salinity minimum at about 800 meters (2,625 feet) for the section in Figure 3. The salinity maximum is caused by the presence of Subtropical Underwater, and the minimum indicates the presence of Antarctic Intermediate Water. The salinities below 600 meters (1,970 feet) in Figure 4 also indicate the presence of Antarctic Intermediate Water, but the sampling depths were too shallow to indicate the lower boundary of the salinity minimum which was probably present.

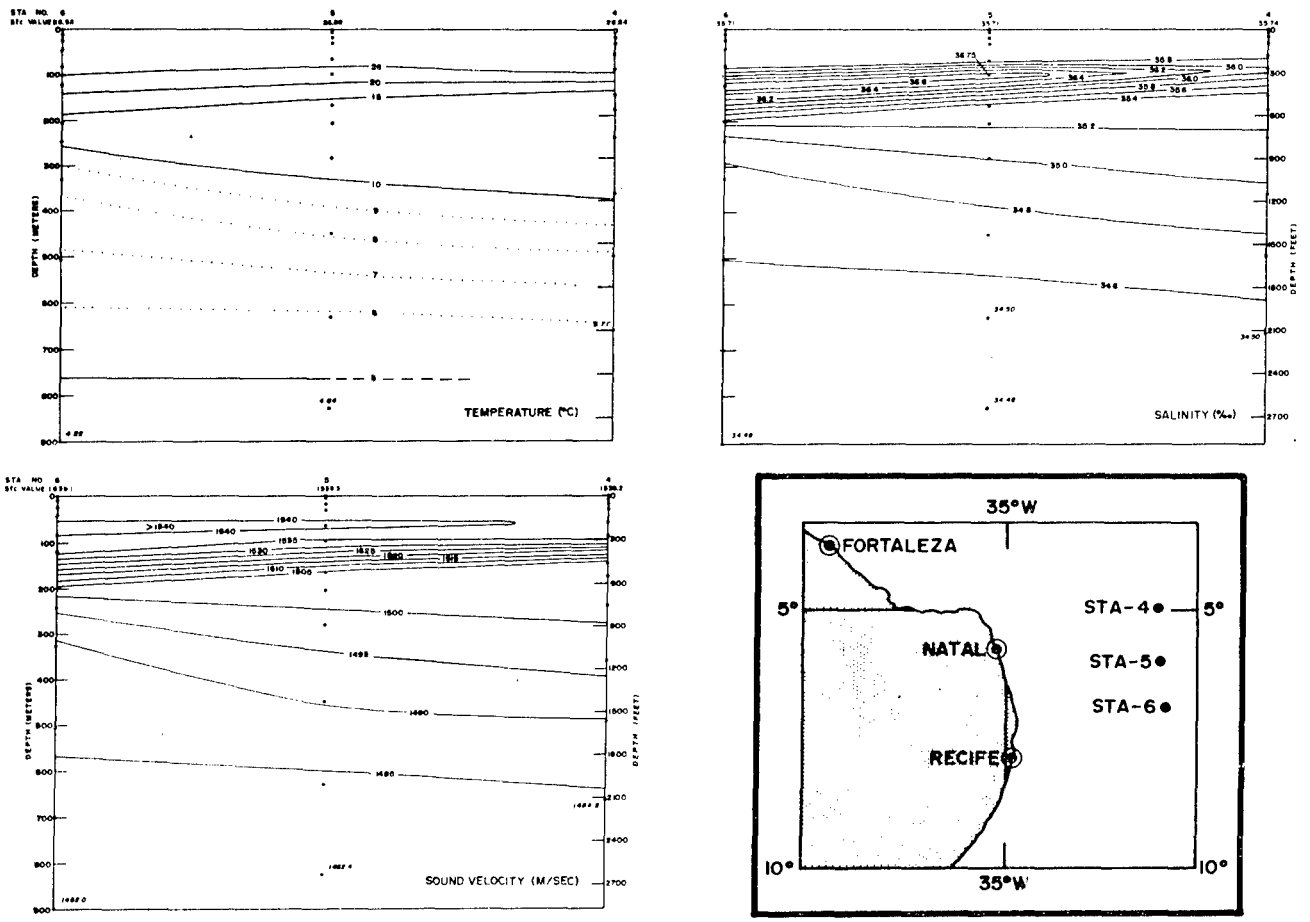

Figure 4. Temperature, Salinity, and Sound Velocity Cross Sections for Stations 4, 5, and 6

A sharp positive salinity gradient appeared in the upper 35 meters (115 feet) at station 1. Apparently, the pycnocline created by this gradient retarded vertical mixing and confined most of the incoming solar radiation to a shallow surface layer. Such a situation would explain the high near surface temperatures and the shallow sonic layer depths observed in this area.

NOTE: In this report, the terms layer depth and sonic layer depth are used interchangeably and are defined as the depth of maximum sound velocity in the upper 1,000 feet of the water column. The terms layer and sonic layer, as used here, refer to the layer bounded by the surface and the depth of maximum sound velocity.

Maximum sound velocities at the six oceanographic stations were generally found near the bottom of the layers influenced by wind mixing (0 to 250 feet). For stations 1 and 2, a sound velocity minimum was found within the Antarctic Intermediate Water. As with salinity, deeper sampling at stations 3, 4, 5, and 6 probably would also have revealed a sound velocity minimum. This sound velocity minimum within the Antarctic Intermediate Water forms the axis of the deep sound channel.

B. Expendable Bathythermographs.

1. General. The XBT data are summarized in Figure 5. When interpreting this figure, it is wise to keep in mind that the layer depth values which are given are average values and that there was often a fair amount of variability in the data for a 2-degree square. Factors such as seasonal changes, afternoon effect, differences in position within a square, and variations in wind mixing must always be considered when extrapolating from an average value to a particular case. Even the average values which are presented could be misleading in some cases because of insufficient data or because the squares were traversed during atypical periods. Despite the above difficulties, Figure 5 is probably of some value for delineating many of the oceanographic features present and for obtaining a general idea of layer depth conditions throughout a large portion of the area.

A comparison of Figure 5 with a similar chart presented in the UNITAS VIII Oceanographic Cruise Summary (Jarvela, 1968) might be useful if the reader wishes to obtain an idea of temporal changes.

2. Caribbean Sea Region. In this area, layer depths varied between 0 and 250 feet (76 meters) and typically occurred at the bottom of an isothermal zone.

In the southeast sector of the Caribbean Sea, some apparently shallow average layer depths were found. These might be caused by the presence of a shallow pycnocline formed by a surface lens of relatively low salinity waters resulting from the outflows of the

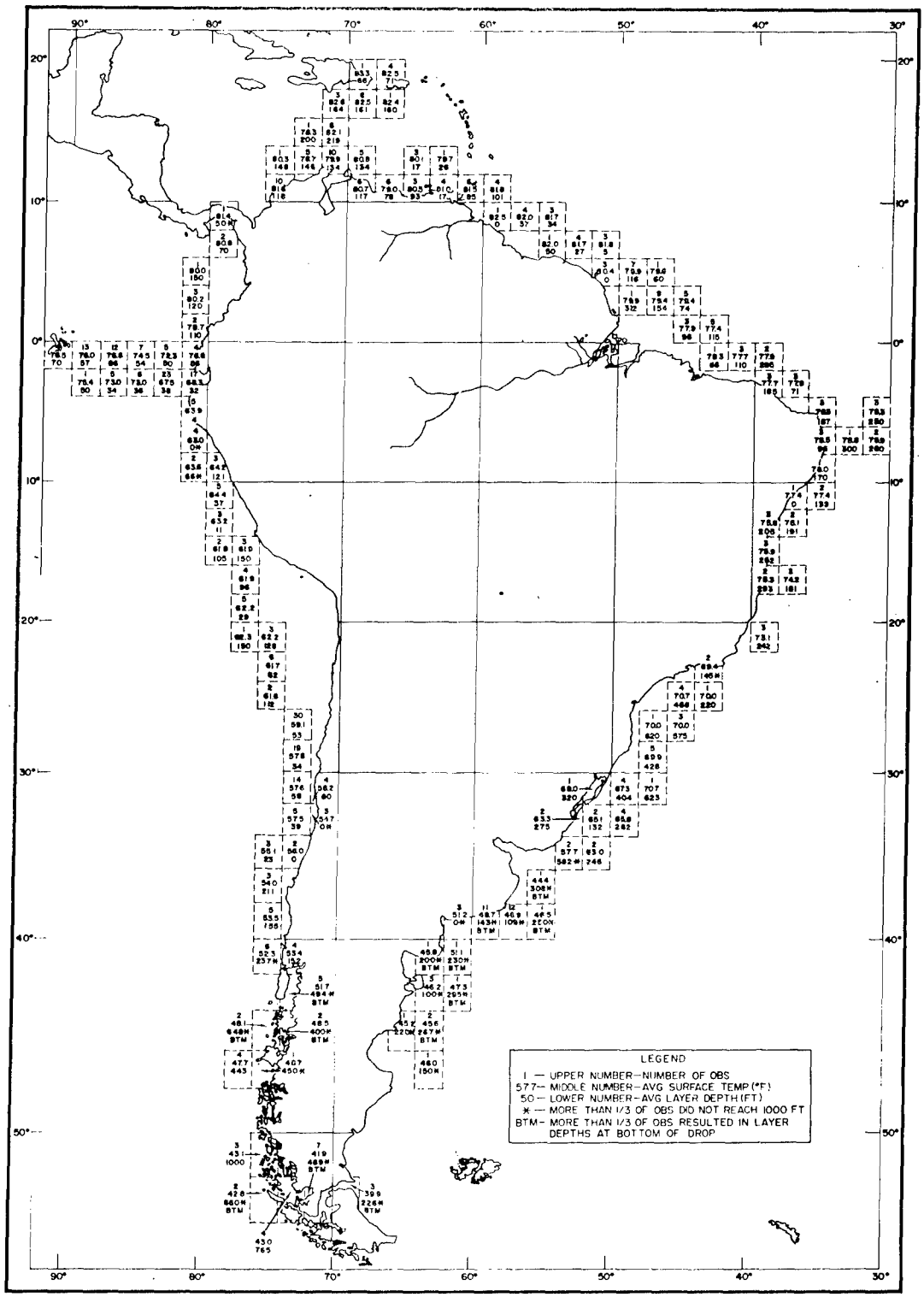

Figure 5. XBT Observations by 2-Degree Squares

Orinoco and Amazon Rivers[1]. Coastal upwelling, which is thought to occur along the Venezuelan Coast, could also help to reduce nearshore layer depths.

3. Guiana Current Region -- Caribbean Sea to 8°S. Here, as in the Caribbean Sea, surface temperatures were high, indicating the tropical nature of the surface waters. Layer depths varied between 0 and 360 feet (110 meters), and the non-zero layers usually extended to the bottom of an isothermal or near-isothermal zone.

The zone of shallow average layer depths found in the Caribbean Sea extends into this region past the mouth of the Orinoco River to the vicinity of the mouth of the Amazon River. This observation tends to confirm the above view that these apparently shallow layers are the result of river influence.

4. Brazil Current Region -- 8° to 22°S. In this region, the Brazil Current (Fig. 2) carries warm water south keeping surface temperatures above 70°F (21°C). Layer depths ranged from 0 to 330 feet (100 meters). Only one zero-layer depth was encountered, and more than half of the XBT's indicated layer depths in excess of 200 feet (61 meters). Again, the layers usually occupied an isothermal or near-isothermal zone.

5. Falkland and Brazil Current Confluence Region -- 22° to 36°S. In this area, surface temperatures indicate that mixing between the warm waters of the Brazil Current and the cool waters of the northward-flowing Falkland Current (Fig. 2) was taking place.

Deep layer depths were common in this region. Only one zero-layer depth was encountered whereas values in excess of 500 feet (152 meters) were observed regularly. A majority of the layers were found in isothermal or near-isothermal layers, but a good portion, especially in the southern part of this area, extended down to well-developed temperature maxima. These maxima could arise when cooler and less saline water from the Falkland Current overrides the warmer and more saline waters of the Brazil Current.

6. Falkland Current Region -- 36°S to the Strait of Magellan. In this region, the relatively low surface temperatures indicate the influence of the Falkland Current. Layer depths range from 0 to 320 feet (100 meters). Most non-zero layers were relatively isothermal, but occasionally, fairly strong positive gradients were encountered.

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[1] The positive salinity gradients associated with such conditions could cause the sound velocity distributions to be considerably different than would be expected from the temperature structures indicated by the XBT's, and consequently it is even possible that indicated layer depths could be in substantial error. Therefore, caution should be exercised when interpreting BT data from such areas.

The XBT's from this region were apparently collected over the Argentine Shelf, as all observations were at depths of less than 400 feet (120 meters).

7. The Strait of Magellan to 40°S. In this region, deep sonic layer depths were common. Many extended to the bottom. Layers with positive temperature gradients (in some cases, they were fairly steep) were common, and some layers had negative temperature gradients as well. Some of the positive temperature gradients might have resulted from overlying cool, low salinity runoff waters.

8. 40° to 4°S. Both the northward-moving Peru Current and intermittent upwelling keep surface temperatures in this area relatively low. Compare, for example, the surface temperatures encountered between 30° and 4°S with those found at the same latitudes off the east coast of South America.

Layer depths were usually shallow in this region. Approximately 40 percent of the observations yielded zero layer depths, and the rest were normally less than 150 feet (45 meters) and occupied an isothermal or near-isothermal zone. Factors contributing to the shallow layers probably include a rise in the thermocline towards the coast, a feature normally found in regions dynamically similar to this one, and the absence of strong winds in the region during the UNITAS IX operations. Since the thermocline should deepen away from the coast, better sonar conditions might have been encountered if the operating areas were farther offshore.

It should be kept in mind that the normal oceanographic conditions in the northern portions of this region are sometimes seriously disturbed by phenomena such as "El Nino" and the "Callao Painter" (see bibliography).

9. 4°S to the Equator. At approximately 4°S, surface temperatures began to increase rapidly towards the north due to a westward turning of a major portion of the Peru Current. Tropical waters lie to the north of this westerly branch, and the temperature gradient caused by the meeting of these waters with the cooler Peru Current waters is evident as far seaward as the Galapagos Islands. (The Galapagos Islands represent the westerly limit of the XBT observations discussed here.)

Layer depths in this area were fairly shallow and ranged from 0 to 150 feet (45 meters). Appreciable thermal gradients in the sonic layers were rare.

10. The Equator to Panama. All of the surface temperatures in this area were high, but there appears to be a slight temperature increase towards the north. Layer depths ranged from 30 to 150 feet (10 to 45 meters), and positive gradients were encountered in almost half of the observed layers.

VII. RECOMMENDATIONS FOR FUTURE WORK

Oceanographic operations during UNITAS X will be conducted on a strict "not to interfere" basis. Consequently, sampling with XBT's probably represents the most practical means of collecting oceanographic data. Studies should be made to determine which areas, along or near the intended ships' tracks, are most in need of additional BT data; XBT sampling densities should be increased in these areas. If research indicates that "opportunity" Nansen cast stations will make only a slight addition to the data already available, they should not be attempted.

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